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Forage from Soybean Provides an Alternative to Its Poor Grain Yield in the Southern Great Plains

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Abstract

The economic potential for soybean (*Glycine max* L. Merr.) as forage, compared to its potential as grain, creates a dilemma for soybean farmers in the southern Great Plains. To better understand these two potential uses, soybean cultivars differing in maturity and growth habit were planted in 14-inch and 28-inch rows on 11 May 2001 and 16 May 2002 near Dallas, TX. The soil was a Houston Black Clay (fine, smectitic, thermic Udic Haplusterts). Plant height, plate meter readings, and forage biomass were measured in July and August and grain yield determined in September. Forage (1.26 to 2.13 ton/acre) and grain yields (9.3 to 20.9 bu/acre) were relatively low and similar between row spacings and between cultivars. Forage quality traits ranged as follows (by dry weight): crude protein (8.7 to 17.2%), acid detergent fiber (24.1 to 33.6%) and neutral detergent fiber (33.2 to 48.9%), in vitro dry matter digestibility (69.2 to 78.6%), and relative feed value (120 to 196). Plate meter readings and plant height were each correlated to biomass in one season but not both. Because of its relatively high forage quality and low grain yields, harvesting any of the soybean cultivars for forage during mid-season would have been more profitable than harvesting for grain, given the hay and grain market prices when the experiments were conducted.

Introduction

In the southern Great Plains, July droughts during the reproductive phase of development often lead to a complete loss of grain yield in soybean. During the flowering and grain fill stages, four factors, when present together, signal the grower that grain yield will be low and unprofitable: (i) a two-week forecast for hot, dry weather; (ii) low subsoil moisture; (iii) physiological stress symptoms such as excessive flower and pod abortion; and (iv) afternoon leaf wilting. For these conditions, income that would have been lost because of drought-induced low grain production could be minimized by harvesting the drought-damaged crop for hay at a stage when digestibility is high.

Cultural practices for grain production as well as those for forage production (timing of hay harvest) could have large effects on the quantity and quality of soybean hay. Twenty years ago, Munoz et al. (15) reported the effects of plant part, plant density (i.e., seeding rate), and developmental phase on soybean hay yield and quality of a soybean grain cultivar (Lee) grown in the Brazos River Valley of central Texas. Their findings indicated that in vitro dry matter digestibility (IVDMD) and protein concentration were much greater in leaf plus pod than in petiole plus stem tissue. In Wisconsin, Hintz et al. (12) studied the effects of seeding rate, row spacing, cultivar, and harvest date on soybean forage yield and quality. They found protein per unit biomass peaked at first flowering (stage R1) (8), then declined until the onset of early seed growth (stage R5), and finally returned to the R1 level at physiological maturity (stage R7). More recently, Darmosarkoro et al. (6) reported that the total biomass yields of forage soybean cultivars grown in Iowa were greater than grain cultivars. In Minnesota, Sheaffer et al. (20) reported that grain type soybean cultivars produced higher quality forage than forage type cultivars before the beginning of leaf senescence. Aside from these reports, however, few data have been published to allow comparison of the potential value of soybean used as hay rather than as grain in the southern Great Plains portion of the US Soybean Belt.

In conjunction with the need to better understand the potential of soybean forage, growers also need an inexpensive method to estimate in-season forage biomass. Instead of actual cutting, drying, and weighing hay, researchers and growers can estimate biomass by using a disk meter or by measuring plant height. Bransby et al. (5) reported the usefulness of a disk meter to estimate forage biomass of tall fescue (*Festuca arundinacea* (L.) Schreb.) and later, a strong relationship was shown to exist between these two traits for several other forage species (10,17). Aiken and Bransby (1) reported strong correlations between tall fescue biomass and disk meter height with the caveat that the relationship varied among individuals operating the meter. These reports dealt with grass forage species and it is unclear how well the disk meter concept applies to crops with different morphology such as alfalfa (*Medicago sativa* L.) or soybean.

Whereas the round-shape (disk) meter appears appropriate for pasture forage, a rectangular-shaped "plate" meter may be just as useful for row crops. Plant height would also seem to be a logical trait to use for estimating biomass of row crops. In one report, Koivisto et al. (14) reported no correlation between soybean forage yield among eight cultivars and plant height. However, we found no other reports testing the relationship between yield and height. Therefore, plate meter and plant height need to be evaluated for their potential in estimating forage biomass in row crops such as soybean.

In order to determine if the production of hay from a soybean crop can be profitable in the southern Great Plains environment, we need to better understand the effects of cultivar, harvest date, and production practices on soybean forage yield and quality. Therefore, the primary objective of our study was to characterize forage yield and quality of one forage soybean cultivar and selected soybean grain cultivars grown with conditions frequently encountered in the Northern Texas Blacklands region of the southern Great Plains. A secondary objective was to determine the usefulness of plant height and plate meter readings for estimating forage biomass in soybean.

Field Cultural Practices

On 11 May 2001, two soybean cultivars, Tyrone (a late-maturing Maturity Group VII forage cultivar bred in Maryland) (7) and the DP5110S (a mid-Maturity Group V grain cultivar) were planted at the Texas A&M Research and Extension Center in Dallas. On 16 May 2002, at a site 0.3 miles from the 2001 site, two additional Maturity Group IV grain cultivars (Deltapine DP4344RR and AG4702RR) were planted along with DP5110S and Tyrone. Soil type was a Houston Black Clay (fine, smectitic, thermic Udic Haplusterts) with pH 8.2 in 2001 and pH 8.3 in 2002. We chose a planting date that might be considered late by this region's soybean growers, but nonetheless a planting date often forced upon growers by abundant April rains. Late planting also increases the likelihood of drought and heat stress during reproductive growth. In both years, inter-row spacings of 14-inch or 28-inch were used. Plots with 14-inch row spacing were 12 rows wide and the 28-inch row spacing plots were six rows wide. All plots were initially 23 ft long but trimmed to 20 ft when an alley was cut between plots in June. Seeding rate was 200,000 seed per acre and seed were inoculated with Cell-Tech 2000 (LiphaTech, Inc., Milwaukee, WI) prior to planting. The following herbicides were applied: Dual (metolachlor) at 1.5 pint/acre (1.43 lb a.i./acre) and Scepter 70G (imazaquin) at 1.4 oz/acre (0.42 oz. a.i./acre) (preemergence on the afternoon of 11 May 2001); and Prowl 4EC (pendimethalin) at 1 qt/acre (1 lb a.i./acre, preplant incorporated in April 2002). Plots with weeds escaping control by the herbicides were kept weed-free by hand hoeing throughout the season.

Plate Meter and Forage Harvest Methods

Plant height (three plants per plot) and plate meter readings (one per plot) were recorded just prior to the hand and mechanical harvests in 2001. Plant height was considered as the distance from the soil surface to the apical meristem. The plate meter is a device made of plywood (14.3 × 24.0 × 0.25 inches or 37 × 61 × 0.63 cm and weighing 2.1 lb or 0.95 kg) that is tethered to a 1.6-×-1.6-inch (4-×-4 cm) hollow block with wire (Fig. 1). The width of the plate matched the narrow row spacing. A 78.7-×-0.79-×-0.79-inch (2-×-2 cm) 2-m-long wooden pole, marked in cm with numbers ascending from the bottom to top, is inserted into the plate and block. The wooden plate (with the wooden pole inserted) is carefully lowered onto the soybean canopy (oriented with the plane of the plate parallel to the soil surface) while the operator supports the entire apparatus by holding the hollow block. The center of the plate rested directly above the row. Plate meter readings indicate the height at which the soybean canopy supports the weight of the plate (i.e., settling height) and may be a useful indirect estimate of biomass. The long side of the plate was held parallel to the row at each sampling, but for August 2001, readings were also taken with the long side of the plate oriented perpendicular to the row. After height and plate readings in 2001, above-ground biomass was hand harvested from 24 inches (60.5 cm) of row (representing 2.33 ft^2 in narrow rows and 4.67 ft^2 in wide rows) that corresponded to the area where the plate meter was taken from the third row for 14-inch rows and the second row for 28-inch rows. The harvest length, 24 inches, corresponded to the plate length. These data were use to determine (i) the relationship between plate meter reading and forage yield and (ii) dry matter distribution among leaves, stalk, and pods. In 2002, four plate meter readings and four plant height readings were taken from near the center of each plot just prior to harvest, but only three consecutive plants were harvested per plot in order to determine dry matter distribution.

Fig. 1. Plate meter placed on soybean canopy (perpendicular orientation for photo) on 9 July 2001.

For “whole-plot” forage yield measurements, plots were end-trimmed to a 16-ft length within one day of harvest. Total above-ground forage from the four center rows of the narrow-row plots and two center rows of the wide-row plots were harvested at two different dates each year: 16 July (66 days after planting, DAP) and 9 August 2001 (90 DAP); and 22 July (67 DAP) and 13 August 2002 (89 DAP). Five feet of undisturbed canopy was present on both sides of the harvested area. Forage was harvested with a mechanical forage harvester and weighed in the field with an automatic weighing system. Subsamples (2.2 lb or 1 kg) were taken, immediately weighed fresh, and then dried at 60°C to constant weight in order to calculate dry matter content.

Forage Quality Analysis

After moisture determination, the entire oven-dry subsample was ground and IVDMD, neutral-detergent fiber (NDF), acid-detergent fiber (ADF), and percent N were measured. Samples were initially ground to pass a 0.079-inch (2-mm) screen and a sub-subsample of the ground subsample was further ground in a cyclone mill (Udy Corp., Ft. Collin, CO) to pass a 0.039-inch (1-mm) screen for total N analysis. The ADF and NDF measurements were performed using the ANKOM200/220 Fiber Analyzer system (ANKOM Technology, Macedon, NY) and protocols (2,3). The IVDMD was determined using an ANKOM Daisy[II] Incubator system for fermentation of samples as described by the manufacturer (4) with the exception that rumen fluid from steers (*Bos taurus* L.) was filtered and mixed with the buffer solution of Goering and Van Soest (9). Total N in forage was measured by automated flash-combustion using a LECO CHN-1000 Analyzer (LECO, St. Joseph, MI). Relative feed value (RFV) was calculated using the following equation:

$$RFV = \{[88.9 - (0.779 \cdot ADF)] \cdot (120 / NDF)\} / 1.29$$

Grain Harvest Procedure and Experimental Design

Plots (15 × 5.0 ft or 4.57 × 1.52 m) were harvested for grain on 24 September 2001 (DP 5110S) or 24 October 2001 (Tyrone). In 2002, all cultivars except Tyrone, which never produced any mechanically harvestable grain were harvested on 23 September. After moisture determination, yields were adjusted to 13% moisture content.

The experimental design for both years was a split-split plot with harvest date the main plot, row spacing the subplot, and cultivar the sub-subplot with three blocked replicates. Because of large differences between years and the two harvest dates, the analysis of variance was conducted for each year and harvest separately as a simple split plot with row spacing the main plot and cultivar the subplot. For plots relating plate and plant canopy height to forage yield, linear regression equations were derived using the Fit Y by X Platform of JMP statistical software (19). An orthogonal fit was used to adjust for variability in X as well as Y variables. The variance ratio was assumed to be 1.

Forage Yield and Quality

In July 2001, forage yields in wide-row plots were greater than in narrow-rows plots and greater with DP5110S than with Tyrone (Table 1). In 2002, forage yields were unaffected by cultivar and row spacing (Tables 2 and 3). Forage from DP5110S had a numerically greater N concentration than Tyrone in both 2001 harvests (significantly greater in August 2001) and the differences were significant in 2002. Row spacing did not affect N concentration in either year or harvest. Using three cultivars from Maturity Groups II and III in Wisconsin where narrow rows are generally advantageous, Hintz et al. (12) reported much greater forage yields than we report here and found that 8-inch (20-cm) row spacing produced between 0.4 and 0.5 ton/acre more forage than the 30-inch row spacing, but crude protein concentration was reduced by 0.4 to 0.8%. Concentrations of N were unexpectedly lower in all of our samples (1.4 to 2.8%) than concentrations seen in previous studies (15,20) that reported values of 2.6 to 5.4%. However, our results agree with theirs in that hay from Tyrone, a forage soybean, had lower N concentration than the grain cultivars. Our N values in 2002 were greater than in 2001, but still lower than those of Munoz (15).

Table 1. Effect of row spacing (RS) and harvest date on forage quality and forage yield of two soybean cultivars (C) grown in Dallas, TX in 2001.

Harvest date	Cultivar	Row space (inch)	Forage yield (ton/acre)	Forage quality trait[a]				
				N (%)	NDF (%)	ADF (%)	IVDMD (%)	RFV
16 July (66 DAP)[b]	DP5110S	14	1.58	1.82	44.6	30.5	73.9	136
		28	1.67	1.92	47.2	32.4	70.7	125
		Avg.	1.62	1.87	45.9	31.4	72.3	130
	Tyrone	14	1.51	1.77	48.2	33.2	70.4	122
		28	1.58	1.72	48.5	33.6	70.1	120
		Avg.	1.54	1.74	48.3	33.4	70.2	121
	LSD (0.05) C × RS		0.07	ns[c]	1.6	1.8	1.5	6
9 August (90 DAP)	DP5110S	14	2.01	1.47	45.3	30.5	71.5	134
		28	2.14	1.60	48.9	32.3	69.2	121
		Avg.	2.07	1.54	47.1	31.4	70.4	127
	Tyrone	14	2.05	1.42	47.0	31.9	70.8	127
		28	1.88	1.39	46.0	32.2	71.5	129
		Avg.	1.96	1.41	46.5	32.1	71.1	128
	LSD (0.05) C × RS		0.07	0.07	1.9	ns	ns	ns

[a] N = nitrogen; NDF = neutral-detergent fiber; ADF = acid-detergent fiber; IVDMD = in vitro dry matter digestibility; RFV = relative feed value.

[b] DAP = days after planting

[c] ns = non significant.

Table 2. Effect of row spacing (RS) on forage quality and forage yield of four soybean cultivars (C) grown in Dallas, TX and harvested on 22 July 2002 (67 DAP[a]).

Cultivar	Row space (inch)	Forage yield (ton/acre)	Forage quality trait[b]				
			N (%)	NDF (%)	ADF (%)	IVDMD (%)	RFV
DP4344RR	14	1.74	2.63	36.6	27.6	75.1	171
	28	1.43	2.57	37.3	27.3	75.8	168
	Avg.	1.56	2.60	37.0	27.5	75.5	169
AG4702RR	14	1.51	2.76	33.2	24.1	78.6	196
	28	1.26	2.66	35.7	25.9	76.4	179
	Avg.	1.41	2.72	34.2	24.8	77.7	188
DP5110S	14	1.60	2.58	36.3	26.6	75.9	175
	28	1.57	2.46	40.6	30.4	72.3	150
	Avg.	1.59	2.52	38.5	28.5	74.1	163
Tyrone	14	1.35	2.43	38.1	28.4	74.9	163
	28	1.51	2.57	39.0	29.1	74.1	159
	Avg.	1.43	2.50	38.6	28.7	74.5	161
LSD (0.05) C × RS		ns[c]	ns	2.5	2.4	3.5	15

[a] DAP = days after planting

[b] N = nitrogen; NDF = neutral-detergent fiber; ADF = acid-detergent fiber; IVDMD = in vitro dry matter digestibility; RFV = relative feed value.

[c] ns = non significant.

Table 3. Effect of row spacing (RS) on forage quality and forage yield of four soybean cultivars (C) grown in Dallas, TX and harvested on 13 August 2002 (89 DAP[a]).

Cultivar	**Row space** (inch)	**Forage yield** (ton/acre)	**Forage quality trait[b]**				
			N (%)	**NDF** (%)	**ADF** (%)	**IVDMD** (%)	**RFV**
DP4344RR	14	1.91	2.21	38.2	27.1	74.8	165
	28	1.88	2.20	40.5	28.7	73.2	154
	Avg.	1.89	2.21	39.4	27.9	74.0	159
AG4702RR	14	1.88	2.23	37.7	26.2	76.1	170
	28	1.60	2.41	38.5	27.1	75.2	164
	Avg.	1.74	2.32	38.1	26.7	75.7	167
DP5110S	14	1.87	2.28	37.7	26.5	74.8	168
	28	2.13	2.06	40.7	28.9	72.0	152
	Avg.	2.00	2.17	39.2	27.7	73.4	160
Tyrone	14	1.91	2.02	39.2	28.2	72.9	159
	28	1.99	2.09	41.8	30.1	70.9	146
	Avg.	1.95	2.06	40.5	29.1	71.9	152
LSD (0.05) C × RS		ns[c]	ns	3.6	ns	ns	21

[a] DAP = days after planting

[b] N = nitrogen; NDF = neutral-detergent fiber; ADF = acid-detergent fiber; IVDMD = in vitro dry matter digestibility; RFV = relative feed value.

[c] ns = non significant.

The low N concentrations of the forage in our study raise the possibility of poor nodulation. Although we did not quantify nodulation, no N was applied and the plants were extremely green in June of both years. Subsequent studies with soybean on a nearby site in the summer of 2003 demonstrated no yield response to synthetic N fertilizer up to 100 lb N per acre (J. J. Heitholt, *unpublished data*). Therefore, we conclude that heat and water stress reduced N_2-fixation to the extent that low forage N concentration resulted in July and August.

In 2001, DP5110S had lower NDF and ADF at the first harvest (66 DAP) and higher N concentration at the second harvest (90 DAP) than Tyrone (Table 1). In both years, IVDMD was similar across cultivars, row spacings, and harvests although minor significant differences were observed (Tables 1, 2, and 3). Gupta et al. (11) reported soybean forage IVDMD decreased as the crop matured. In 2002, RFV was numerically greater than in 2001 and AG4702 exhibited higher RFV than the other cultivars. The second harvest (89 DAP) had lower RFV than the first, but the decline from harvest one to harvest two was greater in 2002 than in 2001.

The relatively low N and relatively high RFV values of hay from our study creates a problem in setting a price for the hay crop. Lactating dairy cattle are the potential primary market for hay producers in the North Texas Blackland region. Hay for this market needs to have RFV values of 150 or greater and crude protein values of 14% (N concentration of 2.24%) or greater (Byron Housewright, *personal communication*). If this hay is priced based on RFV values, it would be overpriced and additional protein (N) sources would be required in the diet. However, if the hay is priced based on crude protein values, it would be underpriced because of the increased rate of passage and energy content of the hay. Howard and Shaver (13) presented a hay value calculator called PRICER, which prices the hay according to N content as well as ADF and NDF but not IVDMD. Using a base price of $75 per ton, PRICER predicts our soybean hay values to range from $49 to $75 per ton and revenues from a low of $98 per acre in July 2001 to a high of $147 per acre in August 2002.

Plate Meter and Plant Height and their Relationship to Yield

Higher parallel plate meter readings were found in wide rows vs. narrow rows (Tables 4 and 5), but this was expected because at equivalent plant densities the plate rested on twice as many plants in wide rows as compared to narrow rows. The fact that spacing and plant density of a soybean canopy greatly affect the plate meter reading suggests that its usefulness may be limited if a single calibration curve is expected for different planting configurations. As expected, our hand harvests tended to provide biomass estimates that were greater than the machine harvest. Plate meter readings in 2001 were correlated to hand-harvested hay yield (Fig. 2). In both 2002 harvests (in which no hand harvests were made), the plate meter reading and biomass were not significantly correlated. In 2002, plate readings were again greater in wide rows than in narrow rows (Table 5). In both years, wide rows produced taller plants than narrow rows, which is in agreement with results reported by Savoy et al. (18). Plant height was generally greater in Tyrone and DP5110S than in AG4702RR and DP4344RR. Plant height was a better predictor of forage yield than the plate meter for 2002 (Fig. 3). Our results indicate that soybean forage yield was crudely related to plant height and plate reading but not significantly each year.

Table 4. Plate meter readings (aligned parallel and perpendicular to the row), plant height, and biomass data from hand harvests of soybean forage taken in coordination with machine harvests in 2001 in Dallas, TX.

Cultivar	Row space (inch)	Plate height[a] Parallel orientation (inch)	Plate height[a] Perpendicular orientation (inch)	Plant[b] height (inch)	Harvest method Hand[c] (ton/acre)	Harvest method Machine (ton/acre)
July 2001						
DP5110S	14	18	-	26	1.73	1.58
	28	27	-	31*	1.93	1.67
Tyrone	14	23	-	27	1.92	1.51
	28	29	-	31*	1.90	1.58
LSD (0.05)		3	-	3	ns[d]	0.07
August 2001						
DP5110S	14	25	24	31	2.57	2.01
	28	24	23	31	2.57	2.14
Tyrone	14	29	27	30	2.97	2.05
	28	30	31	31	2.35	1.88
LSD (0.05)		4	5	ns	0.26	0.07

[a] Plate height values are means of three readings (three plots with one reading per plot).

[b] Plant height values are means of nine readings (three plots with three plants per plot).

[c] Hand-harvested row length was 2.0 ft and represents 2.33 ft^2 for narrow-rows and 4.67 ft^2 for wide-rows.

[d] ns = non significant.

* Indicates values were significant different ($P < 0.05$) between row spacings for that cultivar.

Table 5. Soybean plate meter and plant height readings taken in Dallas, TX in 2002 as affected by harvest date, cultivar (CV), and row spacing (RS). The long edge of the plate was held parallel to the row.

Harvest date	**Cultivar**	**Row space** (inch)	**Plate height** (inch)	**Plant height** (inch)
22 July 2002 67 DAP[a]	DP4344RR	14	22	24
		28	24	27
	AG4702RR	14	19	21
		28	21	22
	DP5110S	14	22	25
		28	25	29
	Tyrone	14	23	25
		28	27	29
LSD (0.05) C × RS			3	5
13 August 2002 89 DAP[a]	DP4344RR	14	22	25
		28	24	29
	AG4702RR	14	19	24
		28	21	23
	DP5110S	14	22	29
		28	27	34
	Tyrone	14	25	30
		28	31	37
LSD (0.05) C × RS			1	5

[a] DAP = days after planting

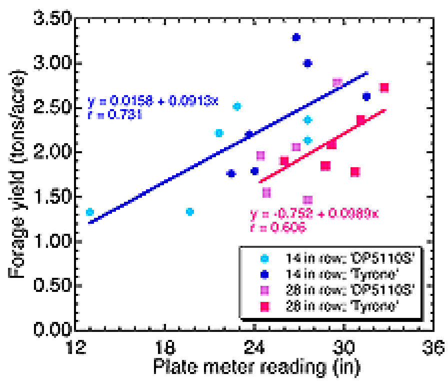

Fig. 2. Relationship between hand-harvested forage yield and plate meter readings of soybean forage in July and August 2001. Yields were adjusted by subtracting pod weight (if present) from total aboveground biomass.

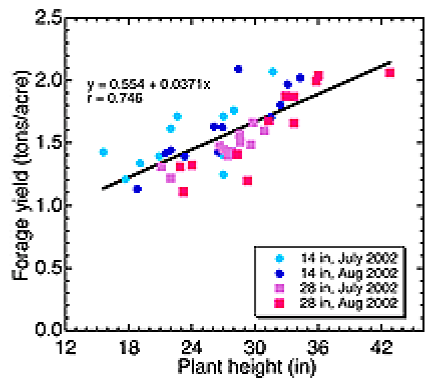

Fig. 3. Relationship between machine-harvested forage yield and height of soybean forage in July and August 2002. Yields were adjusted by subtracting pod weight (if present) from total aboveground biomass.

Plant height of forage cultivars such as Tyrone is often substantially greater than the grain cultivars (6). Since differences in plant height among cultivars in our study were modest, it is possible that Tyrone grew atypically. Our final forage harvest each year was in mid August and this may have prevented us from detecting Tyrone's typical enhanced growth in late August (T. E. Devine, *personnal communication*). On the other hand, Tyrone appeared to have considerable leaf loss in August due to heat and drought, so it was unlikely to have increased substantially in biomass by September although it likely would have grown taller.

Biomass Distribution and Grain Yield

By the second harvest in 2001, DP5110S had a greater percentage of biomass in fruit than Tyrone (13% versus 1%), and Tyrone had a greater percentage in leaves (34% versus 28%) (Table 6). On 23 July 2002 (68 DAP), the percentage of above-ground biomass found in leaf blade tissue was slightly greater for AG4702RR than DP5110S. The percentage of above-ground biomass in petioles plus stems was lowest in AG4702RR. By 13 August 2002 (89 DAP), Tyrone had greater percentage of its above-ground biomass in leaf blade material than the three grain cultivars as expected because of its later maturity. AG4702RR had a greater percentage of its biomass in pod tissue than the other three cultivars. Using soybean cultivars of similar Maturity Group, Darmosarkoro et al. (6) (MG II to VIII) and Sheaffer et al. (20) (MG I to VII) also found genotypic differences in the percentage of biomass found in leaves and stalk tissue with forage-type cultivars having a greater percentage of their biomass in stalk tissue than grain-type cultivars, at least before the onset of leaf senescence. When intended for harvest before mid-August, use of regionally adapted soybean varieties that produce and retain a high percentage of leaves and pods would likely be preferred for monoculture by dairy producers, because these plant parts are likely to be more digestible than stems and also likely to provide greater protein.

Table 6. Dry matter distribution of two soybean cultivars averaged across row spacings and grown in Dallas in 2001 and 2002.

Harvest date	Cultivar	Leaf blade (%)	Petioles + stalk (%)	Pods (%)
11 July 2001	DP5110S	43	56	1
	Tyrone	44	56	0
8 August 2001	DP5110S	28	59	13*
	Tyrone	34*	65*	1
23 July 2002	DP4344RR	41	58	2
	AG4702RR	42	54	4
	DP5110S	38	59	2
	Tyrone	40	60	0
	LSD (0.05)[a]	3	2	ns[b]
13 August 2002	DP4344RR	34	48	19
	AG4702RR	32	44	24
	DP5110S	32	55	13
	Tyrone	41	59	0
	LSD (0.05)[a]	4	5	3

[a] LSD value applies to the 2002 cultivars.

[b] ns = non significant.

* Indicates cultivars were significantly different (P < 0.05) for that harvest.

Due to heat and drought (pan evaporation of 27 to 36 inches) that created a water deficit (Table 7), grain yields per acre were all under 21 bu/acre (Table 8). Yield averages for this part of Texas (Blacklands) from 1998 to 2002 were 17.5, 19.9, 21.6, 20.5, and 22.6 bu/acre, respectively (16). September rains helped the late-maturing Tyrone achieve a low yet respectable grain yield (14.9 bu/acre) in 2001, but drought from August through September prevented pod and seed development in Tyrone in 2002. In years when August and September rains are abundant in the Northern Texas Blacklands region, Tyrone might be a good cultivar to harvest in mid-September for hay or for grain in October.

Table 7. Monthly temperature averages, precipitation totals, and pan evaporation totals for Dallas, TX in 2001 and 2002.

Year	Month	Average temperature Low (°F)	Average temperature High (°F)	Precipitation (inch)	Pan evaporation (inch)
2001	May	62.8	83.1	11.9	8.0
	June	68.5	90.1	3.6	9.9
	July	76.1	96.6	0.1	12.8
	August	73.2	93.7	2.2	10.5
	September	63.3	84.0	2.5	6.1
	Totals	-	-	20.3	47.3
2002	May	61.9	81.0	5.2	8.4
	June	69.3	89.2	2.2	9.4
	July	73.4	92.7	1.7	10.3
	August	72.5	93.9	1.5	11.1
	September	66.4	88.9	1.7	8.9
	Totals	-	-	12.3	48.1

Table 8. Grain yield of four soybean cultivars (C) grown at two row spacings (RS) in Dallas, TX in 2001 and 2002. Yields were corrected to 13% moisture.

Cultivar	Row space (inch)	2001 Grain yield (bu/acre)	2001 Grain yield (lb/acre)	2002 Grain yield (bu/acre)	2002 Grain yield (lb/acre)
DP4344RR	14	-	-	11.5	690
	28	-	-	12.0	721
	Avg.	-	-	11.8	705
AG4702RR	14	-	-	12.0	721
	28	-	-	15.4	929
	Avg.	-	-	13.7	825
DP5110S	14	14.5	870	9.3	558
	28	20.9	1254	17.1	1027
	Avg.	17.7	1062	13.2	792
Tyrone	14	16.5	990	0	0
	28	13.3	798	0	0
	Avg.	14.9	894	0	0
LSD (0.05) C x RS		ns[a]	ns	ns	ns

[a] ns = non significant.

Summary

Soybean hay yields were largely unaffected by row spacing and cultivar. In general, quality traits such as N, NDF, ADF, and RFV were also unaffected by cultural practices except for harvest date, whereby the quality declined from July to August. As a result of the strong plate meter correlation with biomass in 2001 within each row spacing and the strong correlation of plant height with biomass in 2002 across all treatment variables, we consider the plate meter and plant height to be good but inconsistent predictors of forage yield. Although pricing of soybean grain and hay can be variable, our results indicated that hay production would have been more profitable than grain production, if price for grain was $4.20 per bushel and price for hay was $49 to $75 per ton according to University of Wisconsin PRICER formulas with a base price of $75 per ton (13). The PRICER formulas correct the hay value for N content as well as ADF and NDF but not IVDMD. Predicted hay sale revenues from PRICER formulas ranged from a low of $98 per acre in July 2001 to a high of $147 per acre in August 2002. Based on grain yields that were consistently below 21 bu/acre (1.41 Mg/ha), expected revenue from grain was $88 per acre, for grain market prices at the time experiments were conducted. Consequently, harvesting the crop for forage at growth stage R6 (8) is an attractive revenue alternative for soybean growers in the southern Great Plains. However, recent increases in soybean grain prices after the experiment was completed have clearly rejuvenated the grain alternative and must be considered before cutting a soybean crop for hay.

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Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product by the authors or the USDA.

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